EO-1 ICD-018
Rev. A
February 4, 1998

Earth Orbiter-1 (EO-1) Spacecraft to Advanced Land Imager (ALI) Interface Control Document

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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TBR List

Issue	Section Number	Resolution Date	Comment
Drawing A0750 is preliminary		1 December 97	Working on final connector and purge locations
Documentation	2.1		
Mass	3.2.2.1		
Solar calibration offset	3.2.6.5	1 April 98	Range will be 0-7 degrees
Electrical interfaces	3.3.1		
ALI power off mode allocation	3.3.2.2.1		
Interface connectors	Tables 3-3a & 3-3b		
ESD reference	3.3.5.3		

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–	Initial Release	6/23/97	6/24/97
A	Baseline Issue	10/20/97	2/4/98
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IRN 003	EO-1CCR0028	2/3/99	3/15/99

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Section 1. Scope

This interface control document (ICD) defines all interface requirements between the Advanced Land Imager (ALI) and the Earth Orbiter-1 (EO-1) spacecraft. The ICD documents all interface-related agreements concluded between MIT-Lincoln Laboratory (MIT/LL), the ALI contractor, and Swales Aerospace, the spacecraft contractor.

The purpose of this document is to specify the interface requirements in order to assure compatibility between the equipment furnished by the respective contractors. Changes to this document may be proposed by either party for formal approval by the EO-1 Project Office.

This ICD will serve as the controlling technical document between the ALI instrument and the EO-1 spacecraft. This ICD shall apply to all phases of ALI/ EO-1 design, assembly, integration, test, launch, and operations. This document is controlled by the Goddard Space Flight Center (GSFC) EO-1 Project Office.

Section 2. Documents

2.1 Applicable Documents

The following documents of the exact issue shown form a part of the ICD to the extent specified in Sections 3 and 4 of this ICD. In the event of conflict between this ICD and the document referenced herein, the contents of this ICD shall be considered a superseding requirement.

SAI-PLAN-293	**EO-1 Advanced Land Imager Integration Plan**
SAI-PLAN-138	EO-1 Contamination Control Plan
SAI-SPEC-158	EO-1 Verification Plan and Environmental Specification
EO-1 ICD-056	**EO-1 Spacecraft ALI to Spacecraft RS-422 Data Interface Control Document**
AM149-0050(155)	Data Systems 1773 ICD EO-1, Litton Amecom
AM149-0030(155)	EO-1 Uplink Command ICD, Litton Amecom (TBR)
AM149-0031(155)	EO-1 Telemetry Specification, Litton Amecom (TBR)
AM149-0042(155)	WIS Spectral Purity and Implications to EO-1 Spacecraft Pointing, Litton Amecom
AM149-0020(155)	System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom
EWR 127-1	EO-1 Project Safety Document

2.2 Referenced Documents

A0750	ALI Interface Control Drawing
SAI-PLAN-293	**EO-1 Advanced Land Imager Integration Plan**
SAI-STD-056	EO-1 Spacecraft Subsystem Allocations and Description
GSFC-PPL	GSFC Preferred Parts List (latest issue)
MIL-M-38510	General Specification for Microcircuits
MIL-S-19500	General Specification for Semiconductors
MIL-STD-1547	Electronic Parts, Materials, and Processes for Space and Launch Vehicles
MIL-STD-975	Standard (EEE) Parts List
MIL-STD-202	Test Methods for Electronic and Electrical Components
MIL-STD-883	Test Methods and Procedures for Microelectronics

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GEVS-SE	General Environmental Verification Specification for Shuttle & Expendable Launch Vehicle

Section 3. Interface Requirements

3.1 Interface Definition

The ALI experiment comprises a reflective triplet telescope with visible and near infrared (VNIR) and shortwave infrared (SWIR) focal planes, electronic control for the focal plane, an electronics package, and a power subsystem. The experiment is a visible, near infrared (IR), and shortwave IR sensor designed as a technology validation instrument for the next generation of Landsat-like instruments. The ALI interfaces with the spacecraft are defined mechanically/thermally at the spacecraft mounting interfaces, and electrically at the ALI connectors.

3.1.1 Interface Functions

The functions provided to the ALI by the spacecraft, and conversely, are delineated in the following sections.

3.1.1.1 Spacecraft Interface Functions

The following major interface functions shall be provided by the spacecraft:

a. Transmission of commands from the spacecraft via the 1773 bus

b. Provision of primary power from 28 ±7 VDC power bus

c. Provision of mounting interface for ALI instrument to spacecraft

d. Provision of interfaces accommodating mounting, routing, and securing of instrument harness to/on the spacecraft

3.1.1.2 ALI Interface Functions

The following major interface functions shall be provided by the ALI:

a. Transmission of wideband (image) data to the ~~Fiber Optic Data Bus (FODB) instrument terminal~~ **WARP I/F.**

b. Transmission of instrument housekeeping telemetry to spacecraft via the 1773 bus

c. Provision of mounting interface for ALI ~~telescope~~ **instrument** to spacecraft

d. Provision of mounting interfaces for GSE handling fixture attach points on the ALI

3.2 Mechanical Interface Requirements

The ALI instrument consists of the ~~telescope, telescope shroud~~ **sensor assembly** and two electronic units, and internal interface cabling. ~~MIT/LL shall also deliver an RS-422 harness from the focal plane electronics (FPE) to the FODB instrument terminal~~. **MIT/LL shall furnish material to Swales for fabrication of appropriate harness for RS-422 connection from the ALI FPE to the WARP.** The instrument assemblies are mounted on an instrument pallet, which is mounted to the nadir –facing deck of the spacecraft. Figure 3-1 is a drawing of the spacecraft.

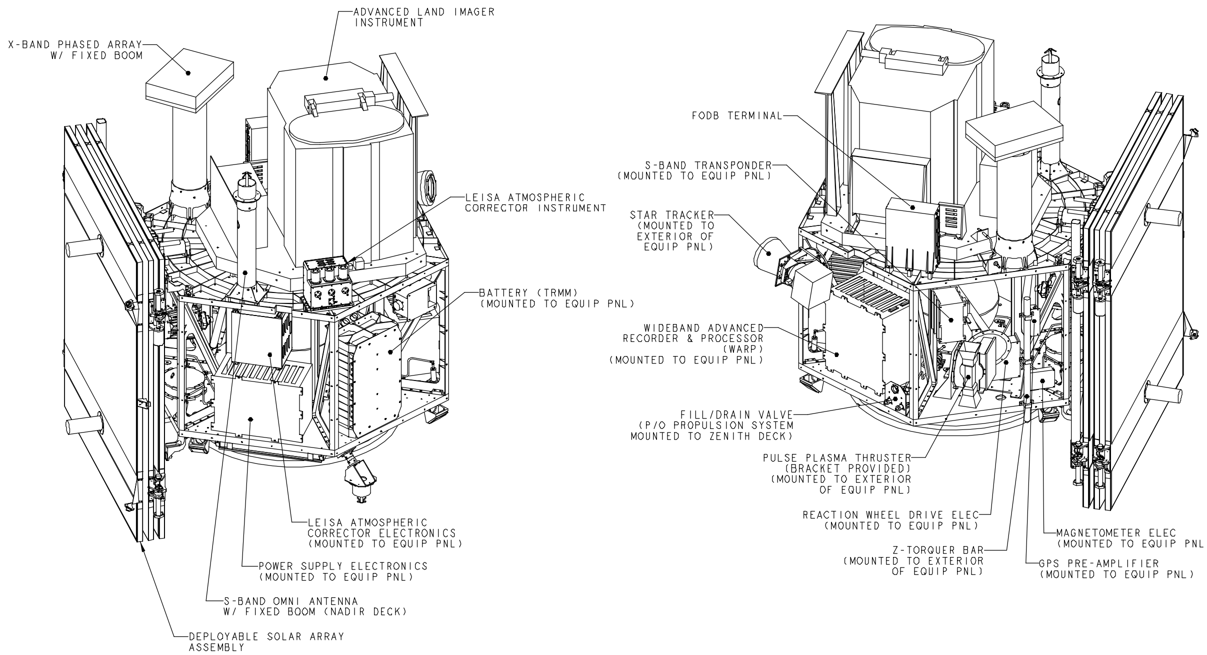

Figure 3-1. EO-1 Configuration (Outer Panels Not Shown)

3.2.1 Configuration

The dimensional drawings of the electronic units and telescope are delineated in ALI Interface Control Drawing A0750. This includes mounting footprints, lift locations, and the location and orientation of electrical connectors. The drawing shows the details of the purge connection and its location.

3.2.1.1 Coordinate System

Orthogonal reference axes are established for the spacecraft and the ALI. The ALI coordinate system is shown in Figure 3-2. The EO-1 coordinate system is shown in Figure 3-3.

3.2.1.2 Fields of View

The ALI ~~telescope shall be located on the spacecraft in accordance with the following field of view (FOV) requirements~~ **FOV (volume of ray paths) is shown in the ALI Interface Control Drawing A0750. The FOV intrusions from the addition of the Hyperion instrument have been investigated by MIT/LL as glint sources (Hyperion solar baffle, and relocated S-band antenna) with the result that they are considered to be unlikely to cause degraded ALI performance.**

~~a. The ALI telescope aperture shall have a clear field of view of 2.26 degrees x 15.5 degrees as shown in ALI Interface Control Drawing A0750.~~

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b. ~~The Telescope's physical entrance port is located in the telescope's tope enclosure plate. The plate is perpendicular to the Z axis and sits approximately 26 inches along the Z axis from the the spacecraft/ALI interface.~~

c. ~~The desired keep-out zone is the volume beyond a constant –Z plane that lies parallel to and Intersects the surface of the telescope shroud.~~

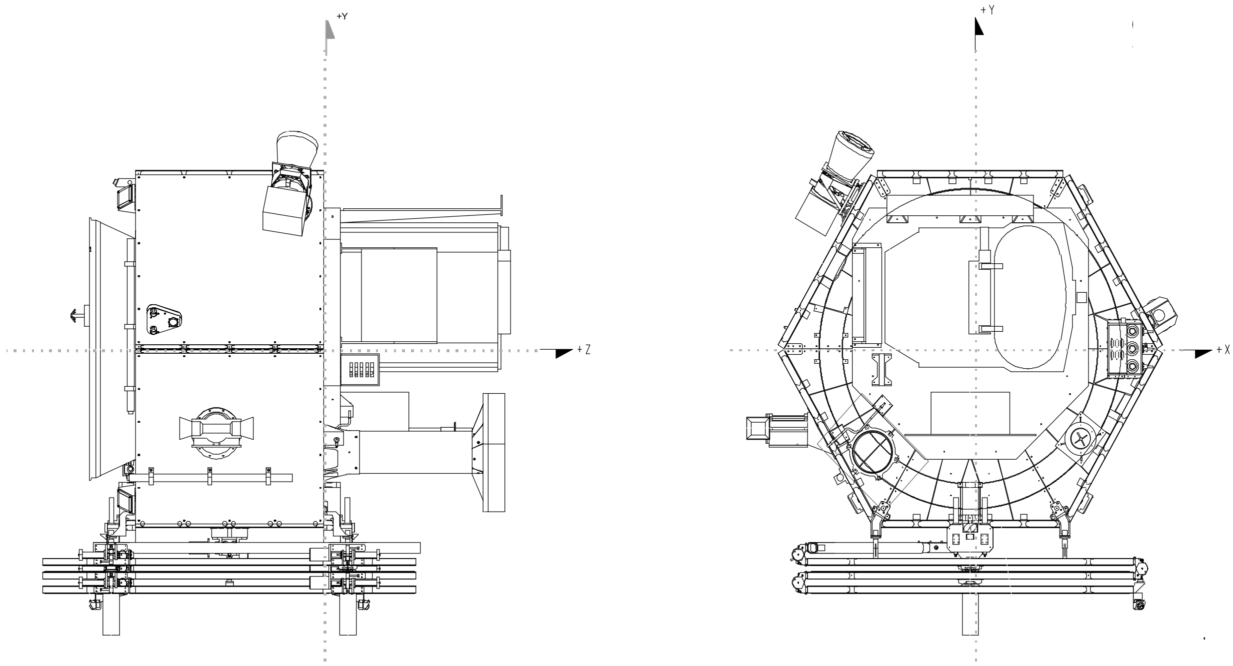

Figure 3-2. ALI Coordinate System

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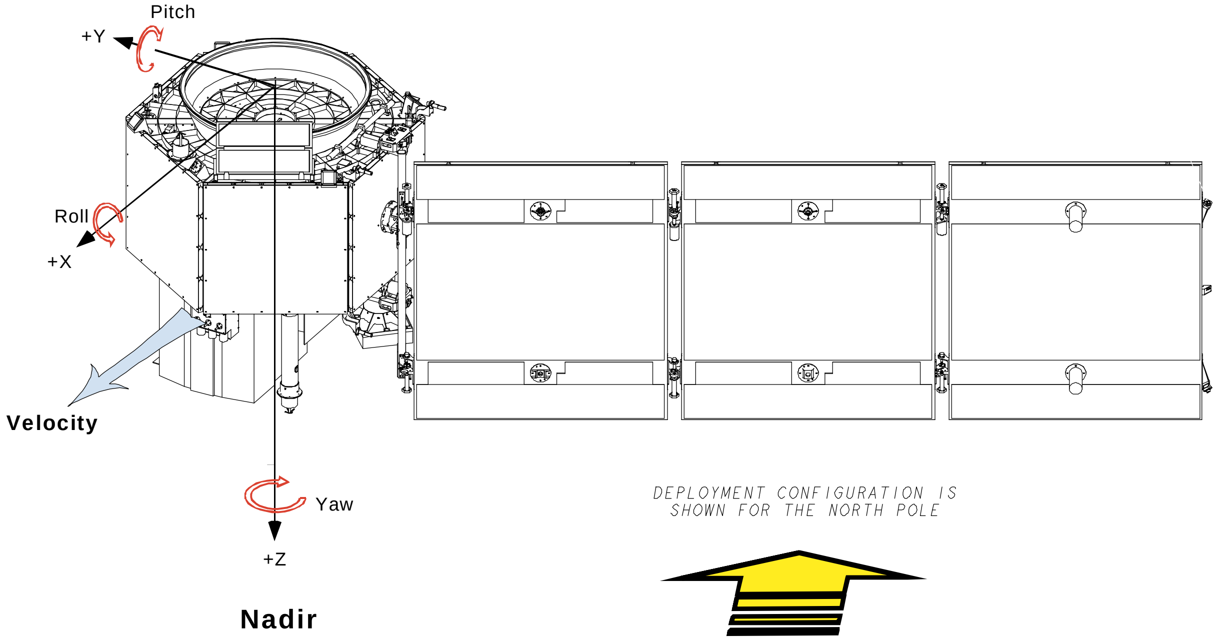

Figure 3-3. Deployed Spacecraft With Coordinate System (Sun is Normal to the Page)

3.2.1.3 Mounting Interface

The ALI telescope pallet is hard mounted to the spacecraft nadir deck with 18 bolts as shown in ALI Interface Control Drawing A0750. Both the pallet and the nadir deck shall have 30 mil raised bosses at the bolt locations. One bolt at each of four footprint extremities of the pallet shall be a shoulder bolt.

3.2.1.3.1 Flatness Specification

The mounting points on the spacecraft shall not be out of plane more than 0.25 mm.

3.2.1.3.2 Drill Template

A drill template shall be used to transfer the instrument pallet mounting hole pattern to the spacecraft. The template will be provided by MIT/LL. The template will use the spacecraft tooling holes as reference points.

3.2.1.3.3 Mechanical Stability

Over the lifetime of the mission, the mounting points shall be stable to 0.25 mm.

3.2.1.4 Thermal Mounting Locations

Thermistors and heaters shall be mounted as shown in ALI Interface Control Drawing A0750.

3.2.2 Mass Properties

3.2.2.1 Mass (TBR)

The total weight of the ALI instrument shall not exceed 90 kg. All changes in mass estimates, including expected growth, shall be reported promptly. The final ALI mass shall be reported to an accuracy of 0.25 kg. The mass of all MIT/LL flight deliveries shall be 100 kg or less.

3.2.2.1.1 ALI Mass

The mass of the ALI is without the RS-422 harness from the FPE to the ~~FODB instrument terminal~~. **WARP I/F.** The mass of the ALI shall be 93 kg or less.

3.2.2.1.2 RS-422 Mass

The mass of the RS-422 harness from the FPE to the ~~FODB~~ **WARP/IF** instrument terminal shall be 7 kg or less.

3.2.2.2 Center of Gravity

The center of gravity (CG) of the instrument shall be measured to 5 mm accuracy in X and Y, and 20 mm accuracy in Z, relative to the spacecraft coordinate system. The CG of the instrument shall be within the volume defined by a right-angle box with corners at (-1, 0, 8) and (1, 6.5, 12) inches in the ALI coordinate system.

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3.2.2.3 Moment of Inertia

The moment of inertia (MOI) and products of inertia of the ALI shall be calculated with 5 percent accuracy. The MOI shall not exceed I_{XX} = 55,000 lb. in^2, I_{YY} = 45,000, and I_{ZZ} = 32,000.

3.2.3 Mechanical Design and Analysis Requirements

3.2.3.1 Structural Design Safety Factors

All hardware shall be designed and analyzed to the applicable safety factors defined in Table 3-1. The analyses shall indicate a positive margin of safety. MIT/LL is also applying a safety factor of 1.25 on microyield.

Table 3-1. Material Factors

All Flight Hardware Except Pressure Vessels	Test Qual	Analysis Only
Material yield factors	1.25	2.0
Material ultimate factors	1.4	2.6

All ground support handling hardware shall have a design factor of safety of 5 (ultimate loads) and test to a minimum factor of safety of 2 without any permanent deformation occurring.

3.2.3.2 Structural Test Safety Factors

All hardware shall be tested to safety factors defined in Table 3-2. If hardware is designed to the “analysis-only” safety factor in Table 3-1, then no strength test (quasi-static limit load) is required.

Strength testing on the flight ALI model can be waived if the following conditions are met:

1. The system-level qualification hardware (e.g., the ALI structural-thermal model), which is similar to flight hardware, is strength tested per Table 3-2.
2. The flight hardware is strength tested per Table 3-2 at the unit or subsystem level.

Table 3-2. Limit Load Factors

Launch Loads	Qual Level	Protoflight Level	Acceptance Level
Quasi-static limit load	1.25* limit load	1.25* limit load	N/A
Sine vibration	1.25* limit level (see Note 1)	1.25* limit level (see Note 1)	1.0* limit load (see Note 1)
Random vibration	limit level + 3 dB 2 minutes/axis	limit level + 3 dB 1 minute/axis	limit level 1 minute/axis
Acoustics	limit level + 3 dB 2 minutes	limit level + 3 dB 1 minute	limit level 1 minute
Shock			
Actual device	2 actuations	2 actuations	1 actuation
Simulated	1.4 limit level 2* each axis	1.4 limit level 1* each axis	limit level 1* each axis

NOTE 1: 25 - 35 Hz 1.5 oct/min; 5 - 25 and 35 - 50 Hz: 4 oct/min for protoflight and acceptance, 2 oct/min for qualification.

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3.2.3.3 Structural Stiffness Requirement

The ALI shall have a first mode frequency greater than 65 Hz.

A finite element model of the spacecraft will be generated to be used in the launch vehicle coupled loads analysis. To aid in this effort, the mass properties of the deliverable hardware will be required. In addition, the first two fundamental structural modes in each of three satellite directions shall be identified. MIT/LL will supply a finite element model.

3.2.3.4 Stress Analysis Requirement

Stress analyses shall be performed to verify the integrity of the component structure and attachments when subjected to the specified loads with the applicable safety factors. Margins of safety shall be determined, dominant failure modes identified, and this information transmitted to the satellite integrator. Existing mechanical stress analysis reports and data may be used if applicable.

3.2.3.5 Fastener Capacity

The ALI will be attached to the spacecraft panel using threaded fasteners. The pallet-mounting bolts shall be ¼-inch NAS 1578, high torque head, with yield and ultimate load factors of at least 2.0 and 2.6. MIT shall supply the fasteners.

3.2.4 Thermal

The instrument pallet ~~and shroud~~ shall be thermally coupled to the **S/C nadir deck** ~~pallet~~. The **ALICE** ~~instrument~~ electronics box~~es~~ shall be thermally ~~isolated~~ **coupled to the pallet and the Focal Plane Electronics box shall be thermally isolated** from the pallet. The spacecraft is cold biased, using heaters, passive radiators, selective thermal control coatings, and multilayer insulating (MLI) blankets. The ALI pallet shall contact the spacecraft nadir deck at 18 points with no insulation between the nadir deck and the ALI pallet. The spacecraft nadir deck will be held between 0 and 30 degrees C.

3.2.4.1 Heat Input to Instrument Radiators

The radiative heat flux from the spacecraft to the focal-plane radiator shall be between 0 and 4 W with 2 W as a goal. The focal plane array (FPA) radiator is sized assuming no direct solar heat input. The conductive heat flux from the **FPE** ~~instrument~~ electronic~~s~~ box~~es~~ and radiator~~s~~ shall be between 0 and 5 W. **The ALICE electronic box shall be thermally coupled to the instrument pallet. Thermal model details of the ALICE mounting arrangement shall be transmitted to the spacecraft contractor.** The radiators are sized assuming hot environment and end of life degraded thermal coating properties. The radiators are sized with enough margin to accommodate partial obstruction of the FOV by spacecraft components such as the X-band antenna boom.

Three reference thermal monitors will be attached to the outside surfaces of the MLI covering the spacecraft deck: one for the focal-plane radiator and one each for the instrument electronics boxes (reference Section 3.3.3.3.2).

3.2.4.2 Design Responsibility

MIT/LL is responsible for the thermal design of the ALI. The spacecraft contractor is responsible for the thermal analysis of the combined instrument and spacecraft. MIT/LL will supply a thermal design, analysis, and model to the spacecraft contractor. If a structure/thermal/optical-performance (STOP) analysis is necessary, MIT/LL will represent the spacecraft using mechanical and thermal data at the interface.

3.2.4.3 Thermal Blankets

MIT/LL is responsible for all externally located thermal control materials for the instrument. MIT/LL will specify the thermal properties of the exterior surfaces of the MLI located on the nadir deck of the spacecraft and at spacecraft components in view of the electronic boxes and radiators. Solar reflections from spacecraft components in view of electronics boxes and radiators shall be minimized wherever possible. . . . The instrument MLI shall extend ~~7~~ ~~cm~~ **1.5 inches** beyond the pallet with 3/4/inch velcro (hooks) attached to the side facing the spacecraft. **MIT/LL will transmit ALI thermal blanket template information to Swales as appropriate.**

3.2.4.4 Safehold Recovery

The thermal system must operate at nominal performance within 24 hours of exiting safe mode (Sun-acquisition attitude) and entering nadir-pointing mode.

3.2.4.5 Survival Heaters

The ~~two~~ **Focal Plane** electronics box~~es~~ shall have redundant, thermostatically controlled heaters to keep the boxes above survival temperature. ~~MIT/LL will attach the thermostats and heaters to the electronics in the location specified by the spacecraft thermal analysts.~~ The power connection for the heaters will be at the ~~RS-422 interface plate.~~ **survival heater power connector bracket.**

Figure 3-4 shows the heater redundancy ~~concept~~ **design** for each of the two electronics boxes.

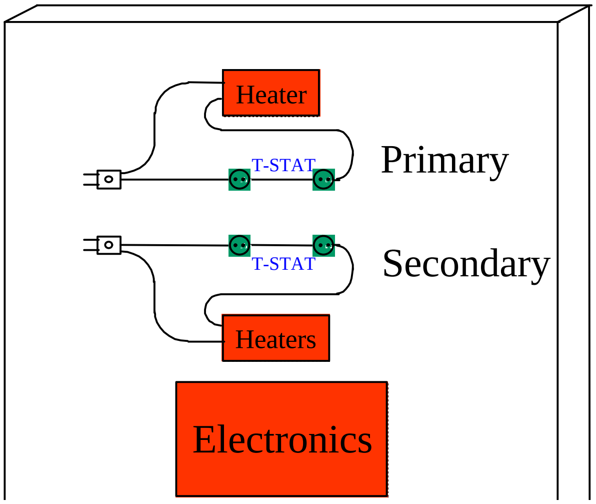
MIT/LL is responsible for determining the specific location of the heaters and thermostats for ~~each~~ **the Focal Plane** electronics box. ~~The maximum current limit is specified in Section 3.3.4.2 (See Table 3-4)~~

3.2.5 Alignment

The total worst-case repeatable mechanical mounting alignment of the instrument with the spacecraft shall be less than 15 minutes of arc. No provisions shall be made for making alignment adjustments. With the use of a 1-inch optical cube, the mounting of the instrument to the spacecraft coordinate system shall be measured/determined to an accuracy of better than ±30 arc seconds.

3.2.5.1 Optical Cube

The location and orientation of the optical cube is shown in ALI Interface Control Drawing A0750.



Concept Philosophy:

Primary thermostat settings are set at a higher set point than the ***secondary*** set points. For example:

Primary:

Close @ -~~3~~ **-1** °C, Open @ ~~3~~ **6** °C

Secondary:

: Close @ -~~12~~ **-10** °C, Open @ -~~6~~ **-3**

Protects against single thermostat failure and line failure.

Figure 3-4. Survival Heater Redundancy Concept

The line-of-sight of the instrument shall be referenced to the optical cube. An error budget of alignment uncertainties shall show that the vector is known within the accuracy of the instrument or to 1 arc minute, whichever is greater.

3.2.6 Pointing Requirements

3.2.6.1 Control and Knowledge

The spacecraft and instrument shall meet the pointing requirements as defined by the Wedge Imaging Spectrometer (WIS) Spectral Purity Error Budget contained in the WIS Spectral Purity and Implications to EO-1 Spacecraft Pointing, Litton Amecom document AM149-0042(155).

3.2.6.2 Stability

The spacecraft will be designed and operated to minimize jitter. The structure is stiff, the solar array first mode is >1 Hz, and the reaction wheels have minimal vibration. During an observation, the solar array will be parked and the reaction wheel speed offset to avoid zero crossings. During observations, the spacecraft will record gyro data for evaluation by the data analysis team.

3.2.6.3 Avoidance

The attitude control system has no autonomous Sun-avoidance or Moon-avoidance error checking or restrictions.

3.2.6.4 Uncompensated Momentum

The ALI shall not generate any uncompensated momentum within the 5 minutes preceding an observation. This restriction does not apply during solar calibration.

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3.2.6.5 Solar Calibration

The spacecraft shall be able to point the ALI boresight toward the Sun with an offset of ~~TBR degrees, in the range between 0 and 7~~ **7.02** degrees in the +Y direction.

3.2.6.6 Lunar Calibration

The spacecraft shall be able to perform a Raster scan of the Moon such that the scan rate is either 0.137 deg/sec or 0.275 deg/sec. The Raster scan shall have five steps to cover each detector chip.

3.2.6.7 Safe Mode

The spacecraft shall provide power to survival heaters for the ALICE and FPE boxes**.** ~~and, if necessary, a heater for the FPAs (maintained grating).~~

3.2.7 ALI Handling Operations and Lift Points

3.2.7.1 Handling Operations

The ALI integration and Test (I&T) ~~document~~ **plan** includes**, by reference,** the handling and installation procedures for the ALI.

3.2.7.2 Lift Points

~~The maximum allowable manual lift weight during spacecraft integration is 10 kgs~~. ALI Interface Control Drawing A0750 shows the lift points of the ALI. MIT/LL shall provide the ALI lifting slings**.** ~~which shall be designed such that the bottom of the pallet can clear the top deck of the spacecraft, which will be 90 inches below the lifting hook.~~

3.2.8 Access Requirements

Access requirements to the ALI shall be as defined ~~in the~~ ~~ALI I&T~~ **by MIT/LL.** ~~plan.~~Access requirements include connector mate/demate clearances, removal and replacement clearances for electronic components and protective covers, and access to purge fittings.

3.2.9 GSE Aperture Covers

There will be a red flag cover on the ALI telescope aperture. It will be used to protect the aperture door.

3.2.10 Nitrogen Purge

Gaseous nitrogen purge will be maintained to the ALI at all times up to 4 hours before liftoff. During I&T and launch-site operations, the purge may be interrupted for no longer than 2 hours.

MIT/LL will provide a portable nitrogen purge cart, which will be connected to the ALI through up to 100 feet of purge hose whenever the instrument is accessible or in its own shipping container. The satellite shipping container will accommodate the ALI purge requirements. The purge cart will be supplied from **clean, dry oil free** liquid nitrogen boil-off. Provision of liquid nitrogen supply, and maintenance of the purge cart (change out of MIT/LL supplied filters) will be the responsibility of Swales after the ALI is delivered.

3.3 Electrical Interface Requirements

3.3.1 Electrical Interfaces

~~An RS-422 Science data interface connector panel will be located on the instrument pallet near the –X, -Y corner of the pallet, as shown in ALI Interface Control Drawing A0750~~. **ALI RS-422 science data will be transmitted via a dedicated harness which connects the ALI FPE directly to the WARP. This harness will be fabricated at MIT/LL and then provided to Swales for completion (dressing and termination at the WARP end).** Power and 1773 connections are at the ALICE electronics box. The power connection for the electronic box survival heater is also **at the survival heater connector panel.** ~~at the interface panel~~. Figure 3-5 is an electrical block diagram of the ALI.

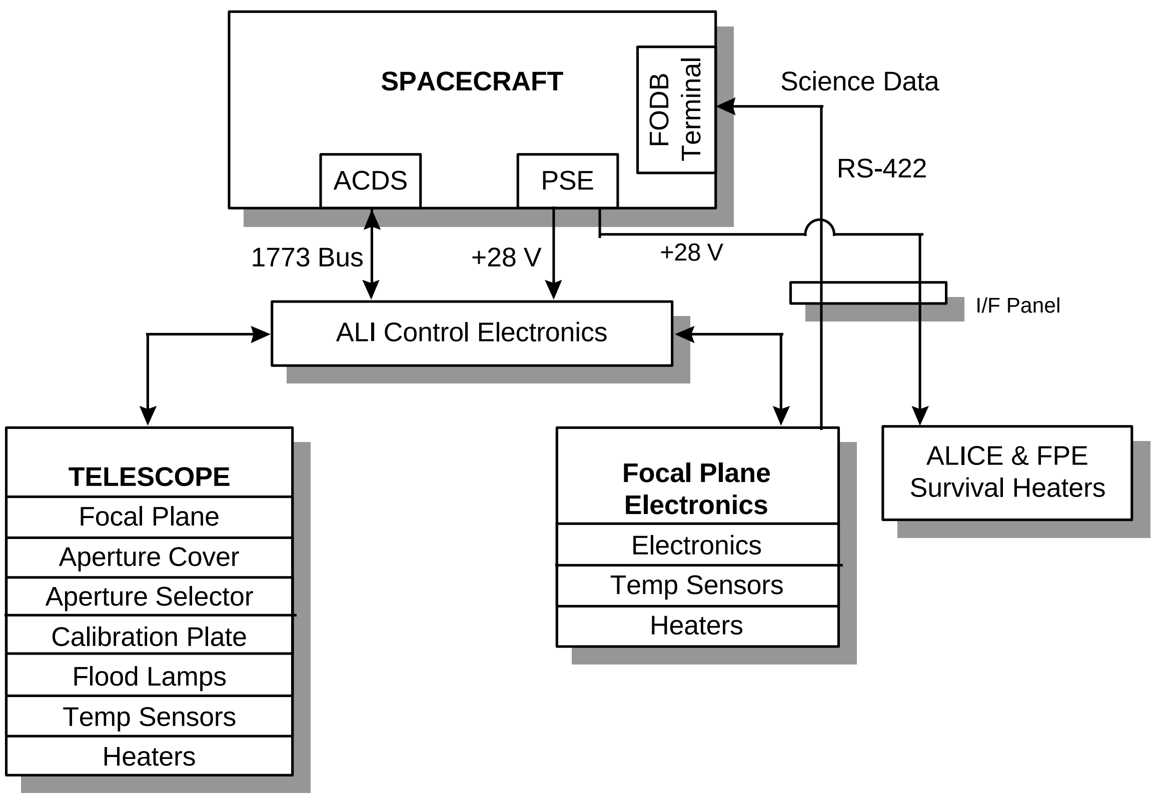

Figure 3-5. Instrument Electrical Block Diagram

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3.3.2 Power Requirements

3.3.2.1 Description

The spacecraft operating bus voltage is 28 V ±7, with power characteristics as specified in System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM149-0020(155). The instrument provider shall ensure that the instrument shall successfully operate within this power regime.

3.3.2.2 Power/Load Characteristics

Power and load characteristics are specified in System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM149-0020(155).

3.3.2.2.1 Power Distribution

The ALI power consumption is given in the following table. Values are derived from measurements of flight hardware.

Table 3.3-1 ALI Power Distribution @ 28V

Unit	Standby at 40C (Watts)	Data Collect* at 40C (Watts)	Standby at 30C (Watts)	Data Collect* at 30C (Watts)	Standby at -10C (Watts)	Data Collect* at –10C (Watts)
FPE	8.4	26.5	8.4	26.5	8.4	26.5
ALICE	18.8	18.8	18.8	18.8	18.8	18.8
FPA** radiator	4.8	4.8	7.8	7.8	15.4	15.4
FPA** conductor bar	1.8	1.8	1.8	1.8	1.8	1.8
Truss Heater	3	3	2.5	2.5	0	0
Total	36.8	54.9	39.3	57.4	44.4	62.5
FPE	8.4	26.5	8.4	26.5	8.4	26.5
ALICE	18.8	18.8	18.8	18.8	18.8	18.8
FPA** radiator	4.8	4.8	7.8	7.8	15.4	15.4
FPA** conductor bar	1.8	1.8	1.8	1.8	1.8	1.8
Truss Heater	3	3	2.5	2.5	0	0
Total	36.8	54.9	39.3	57.4	44.4	62.5
Mechanism	Operation Duration (Seconds)			Power (Watts)		
Floodlamps	16			15.4		
Aperture Selector	16, Deploy 16, Stow			11.2		
Calibration Diffuser	5, Deploy 5, Stow			11.2		
Aperture Cover	12, Open 12, Close			25.2		

***Approximately 5 watts dissipated in the science data cable's resistor terminations.**
**** FPA at 220K.**

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ALI Power Distribution During Outgas Mode at 28V (Watts)

Unit	Power Watts
Outgas heater	**22**
Radiator heater	**24**
FPA Rail heater	**5**
Truss heater	**10**
FPE (Standby)	**8.4**
ALICE	**18.8**
Total	**88.2**

3.3.2.2.2 Noise Suppression

All inductive loads associated with the instrument, such as relay coil circuits, shall be provided with suppression circuits to prevent excessive transients and associated EMC noise due to power interrupts as per System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM149-0020(155).

3.3.2.2.3 Load Profile

The typical load profile of the instrument is ~~illustrated~~ **given** in **Table 3.3-2** ~~Figure 3-6~~. ALI will be in its idle mode when not gathering data or preparing for gathering data. During safehold (satellite in Sun-acquisition attitude), power to the ALI will be off.

3.3.2.2.4 Fusing

The power service to the ALI is switched by a solid-state power controller with a current limit of 15 amps. (The switch is derated to 10 amps.) The controller acts as a circuit breaker and can be reset on orbit.

3.3.3 Command and Telemetry Requirements

All ALI commands and housekeeping telemetry are received from and sent to the spacecraft via the 1773 interface. Details are described in the ~~command and telemetry handbook.~~ **EGSE-2 and -3 S/W Database.**

3.3.3.1 Prime Science Data

Science data is transmitted from the ALI via RS-422, with specifications detailed in the Wideband Advanced Recorder/Processor (WARP) interface documentation.

3.3.3.2 Mission Elapsed Time/Universal Time Interface

Mission elapsed time (MET)/universal time (UT) shall be received via the spacecraft 1773 bus in the form of a time packet broadcast as described in Data Systems 1773 Interface Control Document EO-1, Litton Amecom document AM149-0050(155). The time sent in the time packet is valid at the previous time tone broadcast. The frame start time for ALI science data shall be reported in the 1773 housekeeping data.

Table 3.3 - 2 ALI Typical Power Profile

Time	Condition/Event	Power (Watts)
Equatorial plane crossing (time = To)	**Standby at 30C**	**39.3**
To + 80 minutes	**Enable Data Collect Mode for 10 minutes**	**57.4**
To + 88 minutes, 50 seconds	**Open aperture cover (12 Sec.)**	**82.6**
To +89 minutes, 2 seconds	**Collect data (30 Sec.)**	**57.4**
To + 89 minutes, 32 seconds	**Floodlamp calibration (16 Sec.)**	**72.8**
To +89 minutes, 48 seconds	**Close aperture cover (12 Sec.)**	**82.6**
To + 90 minutes	**Return to Standby at 30C**	**39.3**
To + 100 minutes	**Equatorial plane crossing**	**39.3**

Typical Data Collect orbit timeline and power load profile for 30C spacecraft interface temperature
Average orbital power = {90 x 60 x 39.3 +(8 x 60 + 50 + 30) x 57.4 +24 x 82.6 + 16 x 72.8}/6000 = 41.3 Watts

3.3.3.3 Housekeeping Requirements

The ALI will have several housekeeping monitors, including current monitors, thermal monitors, and a serial digital status report. When the ALI is in the standby or data-gathering mode, housekeeping rate will be 1024 bps or less. Otherwise, in the idle mode, housekeeping rate will be 192 bps less.

3.3.3.3.1 Prime Power Current Monitors

Prime power current monitors are contained within the EO-1 spacecraft power distribution. The ALI will monitor current distribution to instrument components and incorporate this information into housekeeping telemetry.

3.3.3.3.2 Thermal Monitors

The EO-1 spacecraft will provide the thermal monitors on the spacecraft nadir deck to provide a gross measurement of the ALI thermal balance, to provide a thermal measurement for EO-1 thermal balance, and for control during safehold. Any critical internal temperature monitors must be coordinated with the spacecraft integrator.

3.3.4 Interface Connectors and Pin Assignments

There are four electrical connections: optical (1773), power, science-data, and survival-heater power.

3.3.4.1 Description

The instrument provider will fabricate, qualify, and provide to the spacecraft integrator all instrument interconnecting flight harness. The spacecraft will supply harnessing up to the **FPE,** ~~electrical interface plate and~~ up to the ALICE box (1773 and power), **and to the survival heater power connector bracket.**

The 1773 connections are specified in Data Systems 1773 ICD EO-1, Litton Amecom document AM149-0050(155), and the RS-422 science-data connections are specified in the WARP interface documents.

The electrical connections from the spacecraft to the ALICE box (1773 and power) shall be on the -X face of the ALICE box.

3.3.4.2 Connectors

All interface connectors ~~[see Tables 3-3a (TBR) and 3-3b (TBR)]~~ adhere to the specifications as delineated in System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM149-0020(155). ~~Also refer to Section 3.5.5 for EMI consideration.~~

~~The primary side, "Htr A", is limited to 1 amp, maximum current. The redundant side, " is also limited to 1 amp.~~

Table ~~3-3~~ **A-1** (a - **d** ~~b~~) delineates the **J Numbers,** connectors, pin assignments, and wiring interfaces for the ~~power connection~~ **ALI electrical interfaces.**

Also refer to Section 3.5.5 for EMI consideration. **Connector Specifications are shown on Swales drawings A5014A EO-1 ALI/ALICE Heater Interface Bracket and A8068 EO-1 WARP to ALI Science Data.**

3.3.4.3 Connector Mounting Configuration

The configuration drawings in Section 3.2 (see Figure 3-2) show the connector location and orientation on the instrument electronics box and for the ~~interface plate.~~ **survival heater power connector bracket.**

3.3.5 Electromagnetic Compatibility

3.3.5.1 EMC Requirements

~~Table 3-4 describes how~~ The ALI shall meet the EMC requirements as specified in the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM149-0020(155).

3.3.5.2 Grounding

The grounding scheme utilized in any subsystem or instrument shall be consistent with the grounding philosophy of the payload integrator as described in the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM149-0020(155). **The instrument ground point is shown on the ICD drawing A0750. All external surfaces and MLI layers shall be grounded as per the AM149-0020(155).**

3.3.5.3 ESD

All external surfaces and MLI layers shall be grounded as per the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM149-0020(155) (TBR). **After delivery, ALI operations, procedures and plans shall be in compliance with ESD Control Requirements given in NHB5300.4(3L).**

3.3.6 Harness

All internal ALI harnesses shall be mounted to ALI components such as the pallet.

3.3.7 Electrical GSE

MIT/LL shall deliver EGSE to spacecraft I&T when the ALI is delivered. EGSE will be compatible with spacecraft EGSE. EGSE will be able to

- Simulate the focal-plane data
- Collect, store, and verify received focal-plane data
- Transmit and process ALI commands and telemetry

3.4 Ordnance Requirements

There are no electro-explosive devices used on the ALI.

3.5 Radio Frequency Requirements

There are no ALI radio frequency interfaces.

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3.6 Environmental Requirements

3.6.1 Limit Loads

All hardware shall be designed and tested to withstand the quasi-static limit loads (with applicable safety factors) defined in the EO-1 Verification Plan and Environmental Specification, SAI-SPEC-158. These loads are also listed in Table 3-5. Limit loads are defined as the maximum expected flight loads.

Table 3-5. Limit Load Factors

9.1 g axial compression + 7.3 g in any lateral direction
1.0 g axial tension + 5.6 g in any lateral direction

NOTES: 1. Axial means parallel to the EO-1 satellite thrust (Z) axis.
2. The axial and lateral limit load factors of each of the above two sets are to be applied simultaneously.

3.6.2 Random Vibration Test Levels

Table 3-6 provides information on the random vibration test levels.

3.6.3 Acoustic Test Levels

Table 3-7 provides information on the EO-1 acoustic test levels.

3.6.4 Safety

The ALI presents no unusual safety hazards. Items presenting potentially hazardous conditions are listed below:

a. Purge System, utilizing gaseous nitrogen

b. Deployable aperture door

The ALI shall comply (after delivery) with the requirements of the EO-1 Project Safety document EWR 127-1 as applicable.

3.7 Functional Testing

MIT/LL will deliver functional test procedures that collect and check internal lamp data and the FPE test pattern. The procedure will verify correct command and telemetry functionality of the ALI.

Table 3-6. Random Vibration Test Levels

Frequency (Hz)	Level	
	Acceptance	Protoflight
20	~~0.01~~ **0.02**g^2/HZ	0.01 g^2/Hz
20 - 40	+3 dB/octave	+3 dB/octave
40 - 1000	~~0.02~~ **0.04g2**/HZ	0.02 g^2/Hz
1000 - 2000	-3 dB/octave	-3 dB/octave
2000	~~0.01~~ **0.02**g^2/HZ	0.01 g^2/Hz
Overall	**11.54 grms**	5.77 grms

NOTES:
1. Levels are for each of three orthogonal axes, one of which is normal to the mounting surface.
2. Levels are to be applied at the interface with the EO-1 spacecraft.
3. Test duration is 1 minute per axis.
4. The table shows flight acceptance and protoflight test levels. These levels may be reduced (notched) in specific frequency bands, with Project concurrence, if required to preclude damage resulting from unrealistic high amplification resonant response due to the shaker mechanical impedance and/or shaker/fixture resonances. In general, notching may be used to prevent test loads in the primary structure or major elements of the instrument from exceeding 1.25 times flight limit loads. This typically involves only low-order vibration modes with significant modal effective weights.
5. Flight-type attach hardware (including any thermal washers, etc.) shall be used to attach the test article to the test fixture, and preloads and fastener locking features shall be similar to the flight installation. The clearance between the bottom of the ALI pallet and the test fixture shall be the same as the clearance when installed on the spacecraft deck to preclude unrealistic contacts due to vibration.
6. Cross-axis responses of the fixture shall be monitored during the test to preclude unrealistic levels.
7. During the test, the test article shall be operated in a mode representative of that during launch.

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Table 3-7. EO-1 Acoustic Test Levels

One-Third Octave Center Frequency (Hz)	Sound Pressure Level (dB, re 20 μPa)	
	Protoflight	Acceptance Level
25	—	—
31.5	118.5	115.5
40	121.6	118.6
50	125.6	122.6
63	127.3	124.3
80	127.9	124.9
100	129.1	126.1
125	129.7	126.7
160	129.9	126.9
200	130.6	127.6
250	131.7	128.7
315	132.8	129.8
400	131.4	128.4
500	130.0	127.0
630	127.1	124.1
800	124.3	121.3
1000	122.4	119.4
1250	120.5	117.5
1600	119.6	116.6
2000	119.1	116.1
2500	118.7	115.7
3150	117.7	114.7
4000	116.3	113.3
5000	113.8	110.8
6300	109.9	106.9
8000	105.9	102.9
10000	102.9	99.9
Overall	141.1	138.1

NOTE: Test duration = 1 minute.

Section 4. Deliverables

Item	Delivered By	Delivered To	Need Date	Comment
Loads	Swales	MIT/LL	3/1/97	Delivered
ASIST	GSFC	MIT/LL	4/15/97	Delivered
Flight unit ESN	GSFC	MIT/LL	5/31/97	Delivered
Specification of thermal properties of nadir deck MLI	MIT/LL	Swales	6/1/97	Delivered
RSN Operating System	GSFC	MIT/LL	8/1/97	Delivered
ALI Thermal Models	MIT/LL	Swales	8/15/97	Delivered
Drill Template	MIT/LL	Swales	1/1/98	**Delivered**
Focal-Plane Simulator (EGSE-4)	MIT/LL	GSFC	2/1/98	**Delivered**
ALI STM Unit	MIT/LL	**GSFC**	**12/16/98**	**Delivered**
ALI Flight Unit	MIT/LL	**SWALES**	**3/1/99**	**Meet GSFC/Swales I&T schedule**
ALI Handling Procedures	**MIT/LL**	**SWALES**	**01/01/99**	
Test procedures	MIT/LL	Swales/ **GSFC**	**3 weeks before test**	**Installation/ access requirements, functional test &purge procedures & requirements & procedures for satellite optics tests**
Science Data Acquisition System (EGSE-1)	MIT/LL	Swales	**2/12/99**	**Available for tests, but not a deliverable**
Command & Telemetry Processing **S/W Database**(EGSE 2 & 3)	MIT/LL	Swales	**1/29/99**	
Functional test processing S/W	MIT/LL	Swales	**1/29/99**	**Used during tests, but not a deliverable**
Radiometric **pipeline Cal** S/W	MIT/LL	GSFC	**5/30/99**	

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Appendix A Electrical Connection Description

Table A - 1a ALICE J1 5 pin Power Connector Description

Connector part # 311P405-10P-B-12

Pin #	Signal
1	Side A 28V input
2	Side B 28V input
3	nc
4	Side A 28V return
5	Side B 28V return

Table A - 1b ALI J2 9 pin Heater Power Connector Description

Connector part # 311P409-1P-B-12

Pin #	Signal
1	Side A, Heater BX-1 28V input
2	Side A, Heater BX-2 28V input
3	Side B, Heater BX-1 28V input
4	Side B, Heater BX-2 28V input
5	nc
6	Side A, Heater BX-1 28V return
7	Side A, Heater BX-2 28V return
8	Side B, Heater BX-1 28V return
9	Side B, Heater BX-2 28V return

Primary (side A) and redundant (side B) heaters are limited to 1 amp maximum current.

Table A - 1c ALICE 1773 Connector Descriptions

Connector Designation	Signal
J1	Side B 1773 Receive
J2	Side B 1773 Transmit
J3	Side A 1773 Receive
J4	Side A 1773 Transmit

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Table A - 1d ALI FPE J1 100 pin RS-422 Connector Description

Connector part # MDM100SBA174

Pin #	Signal
1	nc
2	Data Bit 00P
3	Data Bit 01P
4	Data Bit 02P
5	Data Bit 03P
6	Data Bit 04P
7	Data Bit 05P
8	Data Bit 06P
9	Data Bit 07P
10	Data Bit 08P
11	Data Bit 09P
12	Data Bit 10P
13	Data Bit 11P
14	Data Bit 12P
15	Data Bit 13P
16	Data Bit 14P
17	Data Bit 15P
18	Data Bit 16P
19	Data Bit 17P
20	Data Bit 18P
21	Data Bit 19P
22	Data Bit 20P
23	Data Bit 21P
24	Data Bit 22P
25	nc
26	nc
27	nc
28	Data Bit 00N
29	Data Bit 01N
30	Data Bit 02N
31	Data Bit 03N
32	Data Bit 04N
33	Data Bit 05N
34	Data Bit 06N
35	Data Bit 07N
36	Data Bit 08N
37	Data Bit 09N
38	Data Bit 10N
39	Data Bit 11N
40	Data Bit 12N
41	Data Bit 13N

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42	**Data Bit 14N**
43	**Data Bit 15N**
44	**Data Bit 16N**
45	**Data Bit 17N**
46	**Data Bit 18N**
47	**Data Bit 19N**
48	**Data Bit 20N**
49	**Data Bit 21N**
50	**Data Bit 22N**
51	**nc**
52	**nc**
53	**nc**
54	**nc**
55	**nc**
56	**nc**
57	**nc**
58	**nc**
59	**nc**
60	**nc**
61	**nc**
62	**nc**
63	**nc**
64	**nc**
65	**nc**
66	**Data Bit 23P**
67	**Data Bit 24P**
68	**Data Bit 25P**
69	**Data Bit 26P**
70	**Data Bit 27P**
71	**Data Bit 28P**
72	**Data Bit 29P**
73	**Data Bit 30P**
74	**Data Bit 31P**
75	**nc**
76	**nc**
77	**nc**
78	**nc**
79	**nc**
80	**Port Clock P**
81	**Port Clock N**
82	**nc**
83	**nc**
84	**nc**
85	**nc**
86	**nc**

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87	**nc**
88	**nc**
89	**nc**
0	**nc**
91	**Data Bit 23N**
92	**Data Bit 24N**
93	**Data Bit 25N**
94	**Data Bit 26N**
95	**Data Bit 27N**
96	**Data Bit 28N**
97	**Data Bit 29N**
98	**Data Bit 30N**
99	**Data Bit 31N**
100	**Shield**

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Abbreviations and Acronyms

ALI	Advanced Land Imager
ALICE	**ALI Control Electronics**
bps	bits per second
°C	degree Celsius
CG	center of gravity
cm	centimeter
dB	decibel
deg/sec	degrees/second
EDU	**Engineering Development Unit**
EGSE	?? electrical ground support equipment
EMC	?? electromagnetic compatibility
EO-1	Earth Orbiter-1
ESD	**ElectroStatic Discharge**
FOV	field of view
FPA	focal plane array
FPE	focal plane electronics
g	**Acceleration equivalent to one Earth gravity**
g^2/Hz	**Units of vibration power input**
grms	**Average acceleration in g units**
GSE	**Ground support equipment**
GSFC	Goddard Space Flight Center
Hz	hertz
I&T	Integration and Test
ICD	interface control document
I/F	interface
IR	infrared
kg	kilogram
lt/min	**Change to L/min**

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MET	mission elapsed time
MIT/LL	Massachusetts Institute of Technology/Lincoln Lab
MLI	**Multi Layer Insulation**
mm	millimeter
MOI	moment of inertia
NASA	National Aeronautics and Space Administration
NMP	New Millennium Program
oct/min	**Octave per minute**
STOP	structure/thermal/optical performance
SWIR	shortwave infrared
TBR	to be resolved
UT	universal time
V	volt
VDC	volt direct current
VNIR	visible and near infrared
W	watt
WARP	Wideband Advanced Recorder/Processor
WIS	Wedge Imaging Spectrometer

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